Sand Creek Massacre National Historic Site

Sand Creek Massacre National Historic Site (SAND) preserves the location of a historically significant incident which occurred during the Indian Wars (SAND Figure 1). On November 29, 1864, U.S. soldiers attacked a peaceful encampment of Cheyenne and Arapaho along Sand Creek (or Big Sandy Creek), killing over 150 people, mostly women, children, and the elderly. The Sand Creek Massacre had a profound influence on U.S.–Indian relations, and altered the Cheyenne and Arapaho cultures, which were already dealing with the effects of recent epidemics. SAND was authorized November 7, 2000, and established April 23, 2007. The site encompasses 5,092 ha (12,583 acres), 965.35 ha (2,385.43 acres) of which are federal.

SAND Figure 1. A view of intermittent Sand Creek from the bluffs (SAND/NPS).

Geologic Background

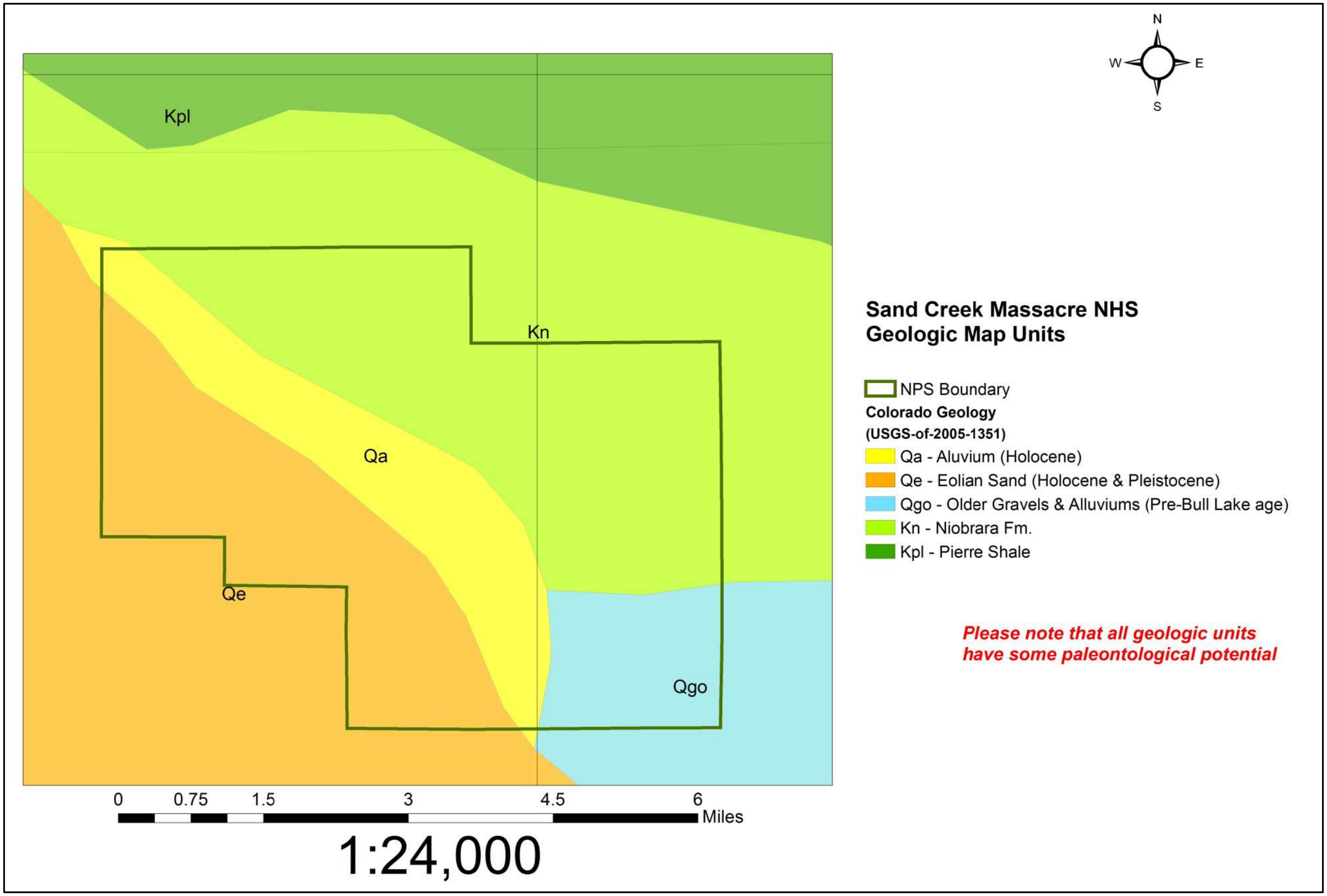
SAND is located in north-central Kiowa County, eastern Colorado. The historic site is within a relatively flat and sparsely-populated area of short-grass prairie. Sand Creek, a tributary of the Arkansas River which passes through SAND, is an intermittent stream. The small community of Eads is about 21 km (13 mi) southwest of SAND. Cheyenne Wells, Colorado is about 28 km (17 mi) north-northeast of SAND, Lamar, Colorado is about 60 km (37 mi) south of SAND, and Burlington, Colorado is about 80 km (50 mi) north-northeast of SAND. Primary documents on the geology and paleontology of the SAND area include Coffin (1967), Sharps (1976), De Vore (1999), Holmes and McFaul (1999), NPS (2000), Koch and Santucci (2003), Noon et al. (2005), Martin (2006, 2011), and Mensing (2007). Because SAND postdates the establishment of the Inventory & Monitoring program, it does not have the same coverage that the other units in the SOPN have, although it was included in the original SOPN paleontological resource inventory and summary (Koch and Santucci 2003).

The rocks and sediments exposed at SAND and the immediate vicinity record Upper Cretaceous marine deposition and Quaternary deposition associated with Sand Creek (see Appendix A for a geologic time scale). Cretaceous rocks of the Niobrara Formation are present immediately beneath the surface of the historic site (Coffin 1967; Sharps 1976). These rocks were deposited in a shallow continental sea known as the Western Interior Seaway or Cretaceous Interior Seaway, which covered much of central North America from approximately 100 to 70 Ma (million years ago). At its greatest extent, the seaway extended from the Arctic to the Gulf of Mexico, bisecting North America (Elder and Kirkland 1993, 1994). Its advances (transgressions) and retreats (regressions) influenced the geology of numerous NPS units both within and outside of the Southern Plains Network (SOPN). Several major cycles of marine transgressions and regressions occurred (Kauffman et al. 1969; Scott et al. 1998), with smaller sea level rises and falls within them (Scott et al. 1998). Volcanoes to the west of the seaway introduced great quantities of ash, today preserved as bentonite layers (Hattin 1975). Stratification of the seawater, limiting oxygen in the depths, appears to have occurred over the course of the cycles (Hattin 1975; Kennedy et al. 1999; Da Gama et al. 2014). The cycles of transgressions and regressions ended after a mountain-building event toward the end of the Cretaceous, beginning roughly 75 Ma, uplifted the region far above sea level. This event, called the Laramide Orogeny, was the first step in the formation of the modern Rocky Mountains. Erosion wore down these peaks until tectonic activity resulted in renewed uplift during the past few million years (Sayre and Ort 2011).

Because of the absence of younger rocks, there is little direct evidence for geologic events that occurred at SAND during the approximately 70 million years that separate the Cretaceous seaway and the Quaternary, which began about 2.6 Ma. The Arkansas River was present to the south by the Quaternary, although its course has been steadily shifting (Sharps 1969). Sand Creek was also present by some point during the Pleistocene, as shown by the presence of multiple terraces. It eroded and reworked Pliocene and Pleistocene upland deposits composed of sediments from the Rocky Mountains (Coffin 1967). During the Late Pleistocene, western Kansas and the vicinity are interpreted as having had a taiga-like mix of conifer forest and aspen parkland, resembling the subalpine taiga of the modern Rockies (Wells and Stewart 1987). Fire events promoted parklands, which were replaced by forests within a century or two. The climate was more equable than present, with cooler, cloudier, and moister summers, and fewer droughts (Wells and Stewart 1987). Humans arrived in the region by the end of the Pleistocene (Hofman 2001).

Because of SAND's late entry into the I&M program, a geologic map has not yet been completed for the site by the Geologic Resources Division. At present, there are three geologic maps that are potential sources: the state geologic map by Tweto (1979); a map of the Lamar 1° x 2° topographic quadrangle by Sharps (1976); and a map of the Sand Creek valley by Coffin (1967). The state map has the advantages of being newest and in digital format, but is at the coarsest scale (1:500,000). The Lamar map is intermediate in age and scale (1:250,000), and is perhaps the most realistic for surficial geology in that it depicts the bedrock as buried rather than at the surface. The Sand Creek valley map is oldest, but has the best scale (1:125,000), shows the position of the township-range-section grid, and is narrowly focused on the Sand Creek valley. Therefore, it is probably the most optimal map of the three for SAND, if the reader takes into account that the Cretaceous rocks of the area are poorly exposed when near the surface.

Geologic units exposed at the surface or present just beneath cover within SAND include the Upper Cretaceous Niobrara Formation (Smoky Hill Chalk Member), and Quaternary eolian (windblown), terrace, alluvial, and valley fill deposits (Coffin 1967; Sharps 1976) (SAND Figure 2). None of these units are known to be fossiliferous within the historic site at this time, but they have the potential to yield fossils (SAND Table 1).



SAND Figure 2. Schematic geologic map of SAND, based on a digital map derived from Tweto (1979).

SAND Table 1. Summary of SAND stratigraphy, fossils, and depositional settings in descending order of age, from youngest to oldest. Details and references can be found in the text.

Formation	Age	Fossils Within SAND	Depositional Environment
Quaternary sediments (alluvium, eolian, and older gravel)	Pleistocene–Holocene	None to date; pollen is most likely, given the historic pollen record	Windblown deposits and deposits associated with fluvial processes predominate
Niobrara Formation, Smoky Hill Chalk Member	Late Cretaceous	None to date; microfossils and bivalves are most likely	Marine

Potential Sources of Paleontological Resources

Fossils have not yet been documented from the following rock units within SAND. However, they are known to preserve fossils elsewhere, and future field investigations within the historic site may result in the discovery of fossils in one or more of them.

Niobrara Formation (Upper Cretaceous)

The Niobrara Formation is a widespread chalky and shaly formation on the Great Plains. This formation is often divided into two members: the Fort Hays Limestone Member and overlying Smoky Hill Chalk (or Shale) Member. The Smoky Hill Chalk Member is the unit immediately beneath the surface at SAND (Coffin 1967; Sharps 1976). Although depicted by Coffin (1967) as at the surface in eastern SAND, the author notes that it is poorly exposed and weathers quickly, so that it is usually concealed by a thin layer of silty clay. In this area, it is composed of thin-bedded chalky shale, more chalky in the upper section, more shaly in the middle section, and with harder limestone beds near the base (Sharps 1976). Although it is dark gray to black when freshly exposed (Coffin 1967), it weathers to a distinctive yellowish-gray color, which can be seen in the soil (Sharps 1976). It is between 150 and 210 m (500 and 700 ft) thick in the area (Sharps 1976), so any kind of deep drilling within the historic site should encounter a significant thickness of it. Thin bentonite beds are observed in some areas, and limestone concretions as much as a meter (3 ft) in diameter are common (Coffin 1967). The exact contact between the Smoky Hill Chalk Member and the overlying Pierre Shale is not known for certain in the area (Coffin 1967; Sharps 1976), but the two can be distinguished by the orange to yellow color of weathered Smoky Hill Chalk versus the drabber yellowish-brown color of weathered Pierre Shale, and the fact that the Pierre Shale is not calcareous (lacks calcium carbonate) (Coffin 1967).

Deposition of the Niobrara Formation occurred within an epicontinental sea over several million years. The age of the base of the formation becomes younger going north, east, and west from southern and central Colorado. According to the fossil content, deposition of the Niobrara Formation began shortly before 89 Ma in adjacent Hamilton County, Kansas (Merewether et al. 2007). Deposition of the Smoky Hill Chalk Member began shortly after, and continued to between 82 and 81 Ma (Da Gama et al. 2014). The first few million years of deposition occurred under relatively well-mixed and well-oxygenated water, with a warm surface temperature and high productivity. Water was drawn from both oceans to the north and south (Da Gama et al. 2014). The middle period of deposition saw the contribution of northern waters become less important, with an increase in terrestrial input and water stratification, and a decrease in oxygenation in the bottom waters. By the end of deposition, the surface water had become notably fresher from the terrestrial input, and the water column was stagnant and strongly stratified, with the bottom water bordering on anoxia (Da Gama et al. 2014). Active volcanoes were present to the west, which provided the ash that eventually altered to form the bentonite beds (Diffendal and Voorhies 1994). The sea deepened throughout deposition (Hattin and Cobban 1977). The chalk of the Niobrara Formation is composed of fecal pellets, which in turn are made up of coccoliths (mineralized plates of plankton) (Da Gama et al. 2014). They may represent the feces of marine microorganisms like the tiny planktonic crustaceans known as copepods, which would have been feeding on coccolith-producing phytoplankton (Longman et al. 1998). Cyclic bedding of limestone with shale and marlstone in the underlying Fort Hays Limestone Member are attributed to climate and orbital variations, although mountain-building to the west and erosional events complicate the signal (Laferriere 1987).

The Niobrara Formation is famous for its fossils, which are found throughout the formation. The Smoky Hill Chalk Member will be the focus here because of its presence at SAND. Common fossils in the Smoky Hill Chalk Member of the Arkansas River region of eastern Colorado include the bivalve *Volviceramus* (formerly *Inoceramus*) *grandis*, oysters, ammonites, and fish fossils, especially scales (Dane et al. 1937). The fossil assemblage of the Smoky Hill Chalk Member over its entire depositional area is documented well enough that faunal changes can be observed over time (Everhart 2005). Microfossils, plant fossils, and invertebrate fossils from the Smoky Hill Chalk Member include nannofossils like coccoliths (Watkins et al. 1993; Shamrock and Watkins 2009), foraminifera ("amoebas with shells") (Loetterle 1937; Frerichs and Gaskill 1988), dinoflagellates (single-celled organisms that move using one or more whip-like flagella), pollen, spores, algae, microscopic plant fragments (Da Gama et al. 2014), rare wood fragments (Everhart 2005), fragments of marine rushes (Simpson 1960), sponges (Everhart 2005), bivalves (including inoceramids and reef-forming rudists), ammonites, belemnites (squid-like cephalopods known from their bullet-shaped guards), squids, barnacles (Everhart 2005; Shimada et al. 2007), rare crustaceans, crinoids (sea lilies), worm tubes (Everhart 2005), invertebrate fecal pellets (Hattin and Cobban 1977), and burrows and trails (Scott and Cobban 1964).

The fossil vertebrate assemblage of the Smoky Hill Chalk Member includes diverse chondrichthyans (including guitarfish, ratfish, and sharks) and ray-finned fish (Everhart 2005; Shimada and Fielitz 2006; Shimada et al. 2007), rare coelacanths, several taxa of turtles, long-necked and large-skulled plesiosaurs, several mosasaur taxa (lizard-like marine reptiles), the marine lizard *Coniasaurus*, the pterosaurs (flying reptiles) *Nyctosaurus* and *Pteranodon*, rare dinosaurs (armored *Hierosaurus* and *Niobrarasaurus*, and the "duck-bill" *Claosaurus*), several birds (most famously the toothed seabirds *Hesperornis* and *Ichthyornis*, the former flightless) (Everhart 2005; Shimada et al. 2007), and coprolites (fossil feces), often containing invertebrate or vertebrate remains (Everhart 2005).

Quaternary rocks and sediments (Pleistocene–Holocene)

The Quaternary deposits of SAND include a combination of eolian (windblown) sand, alluvium, terrace, and valley fill deposits (Coffin 1967; Sharps 1976). The eolian sand deposits are particularly extensive on the west side of the creek (Coffin 1967; Sharps 1976), while loess and slopewash are more common on the east side (Sharps 1976). The deposits have not been formally dated, but may only be as old as the Pinedale glaciation (Sharps 1976), the regional representative of the most recent major glacial advance (approximately 30,000 years maximum). A cross-section through southern SAND shows that the Quaternary deposits can be 15 to 30 m (50 to 100 ft) thick, although they would seem to thin to the north, because the Niobrara Formation is depicted as at the surface in much of eastern SAND (Coffin 1967). The valley fill and terrace deposits average 8 to 9 m (25 to 30 ft) thick, reaching as much as 21 m (70 ft) thick, and are composed of grains from gravel to clay size. The original source for most of the material was igneous and metamorphic rocks in the Rocky Mountains, which were eroded from the mountains during the Neogene and became part of upland deposits, and later reworked farther away by Sand Creek and other creeks. De Vore (1999) depicted three terraces above the modern floodplain and below the bluffs at SAND. Radiocarbon dates from soil show that the second terrace formed around 2000 years ago and the lowest terrace formed around 1000 years ago. The dune sand, which is generally sourced from valley fill, is composed of very fine to very coarse quartz sand grains. It is usually 3 to 6 m (10 to 20 ft) thick, but can be as much as 21 m (70 ft) thick (Coffin 1967).

Mensing (2007) described pollen from several sediment cores taken from two sites in SAND. A core from a creek site, with a depth of approximately 105 cm (41 in), included pollen-bearing sediment above 30 cm (12 in) and below approximately 90 cm (36 in). The upper pollen-bearing sediment has an extrapolated date of 1850 AD at the base, shortly before the massacre (Mensing 2007). The lower pollen-bearing sediment is undated, and so could be hundreds to thousands of years older. At this time, in the absence of dates, the older pollen-bearing sediment is most useful for showing the potential of discovering ancient pollen within SAND, which could be useful for climatological work at the historic site.

There are relatively few reports of Quaternary fossils within a 100 km (60 mi) radius of SAND. For example, the maps of Hay (1924) or the Neotoma paleoecology database (http://www.neotomadb.org/) show little for eastern Colorado and western Kansas. Terrestrial gastropods are a notable exception, with numerous faunas known from the Peorian loess of western Kansas. Small mammals (shrews, rodents) and conifer fragments are also fairly common (Wells and Stewart 1987). The most notable Quaternary site in the area is the Olsen-Chubbuck Bison Kill Site, about 12 km (7 mi) north of SAND. This site yielded the remains of at least 190 individuals of the extinct bison *Bison occidentalis*, killed about 10,150 ± 500 radiocarbon years before present (12,980 to 10,410 calibrated years before present) (Wheat 1972). (Note that radiocarbon dates are not the same as calendar dates, and must be calibrated to approximate calendar years. Dates can be calibrated using a calibration program such as Calib 7.1 [http://calib.qub.ac.uk/calib/] if error ranges are provided. "Present" in "before present" is 1950.) The hunters used tools made of a variety of materials, including bone, Alibates chert from Texas (see the Alibates Flint–Lake Meredith section of this report for more information), potentially fossiliferous Knife River flint from North Dakota, and petrified wood. The site also yielded ephedra, conifer, and angiosperm pollen (Wheat 1972). An archeological site of similar age has been found at Kanorado, Kansas, about 90 km (55 mi) northeast of SAND; interestingly, mammoth and camel bones were also found here at a lower horizon (Holen et al. 2004). Hay (1924) reported observing a Columbian mammoth tooth reputedly from Sharon Springs, Kansas, about 71 km (44 mi) northeast of SAND, on display in Portland, Oregon. Useful online paleontological resources for the southwestern United States include the Neotoma database mentioned above, and Faunmap, which is the vertebrate element of Neotoma (http://www.ucmp.berkeley.edu/faunmap/).

Park Collections

No fossils are currently reported to be in SAND collections, and no SAND fossils are currently reported to be in the collections of other institutions.

Cultural Resource Connections

No fossils have been reported from cultural resource contexts at SAND, although such associations would not be unprecedented. The most likely type of cultural association for this area would be fossiliferous stone used for artifacts. For example, in the Southwest, petrified wood from the Upper Triassic Chinle Formation was often used for artifacts. The majority of parks in the neighboring Southern Colorado Plateau Network have examples (Tweet et al. 2009). Kenworthy and Santucci (2006) presented an overview and cited selected examples of National Park Service fossils found in cultural resource contexts.

Paleontological Resource Management, Preliminary Recommendations

- Staff from the historic site should be encouraged to observe exposed rocks and sedimentary deposits for fossil material while conducting their usual duties. To promote this, staff should also receive guidance regarding how to recognize common local fossils. When opportunities arise to observe paleontological resources in the field and take part in paleontological field studies with trained paleontologists, staff should take advantage of them, if funding and time permit.

- Staff should photodocument and monitor any occurrences of paleontological resources that may be observed in situ. Fossils and their associated geologic context (surrounding rock) should be documented but left in place unless they are subject to imminent degradation by artificially accelerated natural processes or direct human impacts. A Geologic Resource Monitoring Manual by the Geological Society of America and NPS Geologic Resources Division includes a section on paleontological resource monitoring (Santucci et al. 2009). Santucci and Koch (2003) present information on paleontologic resource monitoring.

- Fossils found in a cultural context should be documented like other fossils, but will also require the input of an archeologist or a cultural resource specialist. Any fossil which has a cultural context may be culturally sensitive as well (e.g., subject to NAGPRA) and should be regarded as such until otherwise established. The Geologic Resources Division can coordinate additional documentation/research of such material.

- Contact the NPS Geologic Resources Division for technical assistance with paleontological resource management issues.

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